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ANATOMY OF LYCOPODIUM REFLEXUM¹

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(WITH FIVE FIGURES)

In a former paper,² giving in some detail the results of an investigation of the development and specialization of the steles of 6 species of *Lycopodium*, I reviewed the literature of the subject of the anatomy of *Lycopodium*. The anatomical studies have emphasized "types" of steles as characteristic of various species of *Lycopodium*, among which the radial and parallel-banded arrangements predominate. In my former paper I suggested that it was inadvisable to regard any stelar arrangement as characteristic of a species of *Lycopodium*, since almost all "types" may be found in a single species, and even in a single plant at different levels in the stem.

The plants of *L. reflexum* used in this investigation were collected by Dr. C. R. BARNES and Dr. W. J. G. LAND in the vicinity of Xalapa, Mexico, in 1908. The habitat is described as moist clay soil. The material was preserved in a formaldehyde-alcohol solution and was given to me in this condition by Dr. LAND, to whom I wish to express my thanks. The slides for the investigation were prepared from paraffin serial sections cut transversely 10-15 μ in thickness and stained in safranin-light green and in iron-alum haematoxylin-safranin, both combinations producing excellent results; the former is slightly better for differentiating protoxylem in sections of young stems, and the latter better for older tissues.

Investigation

In a study of the sections of the stem the most important matter of interest is concerned with the so-called "types" of stele to be found in *L. reflexum*; a secondary significant feature is

¹ Contributions from the Department of Botany of the Pennsylvania State College, no. 17.

² HILL, J. BEN, The anatomy of six epiphytic species of *Lycopodium*. BOT. GAZ. 58:61-85. figs. 28. 1914.

the presence of cortical roots. These originate in a manner similar to that described by Miss STOKEY³ for *L. pithyoides*, and show a

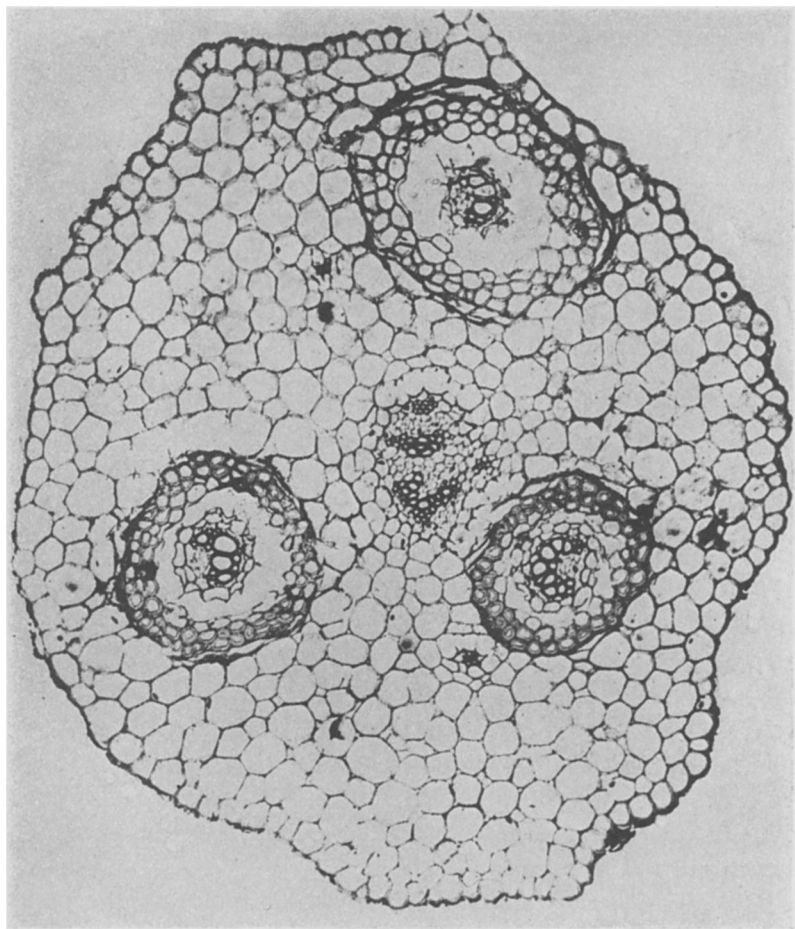


FIG. 1.—*L. reflexum*: transverse section of stem showing small stele and 3 cortical roots; in the roots phloem is surrounded by a crescent-shaped mass of xylem; root stele is surrounded by very thin-walled cells which generally are crushed and broken in sectioning; outer cortex of root composed of thick-walled cells; $\times 120$.

development in the matter of differentiation of the stele paralleling that described⁴ for the stem of *Lycopodium*, in which the xylem

³ STOKEY, ALMA G., The roots of *Lycopodium pithyoides*. BOT. GAZ. 44:57-63. pls. 5, 6. 1907.

⁴ HILL, J. BEN, *loc. cit.*

regions are recognizable long before lignification occurs. In young sections of the roots the metaxylem cells are recognizable early by their increased size and lack of protoplasmic content. The xylem is crescent-shaped, the protoxylem occurring at the ends and bordering the larger arc of the crescent. The mature roots, 2 or

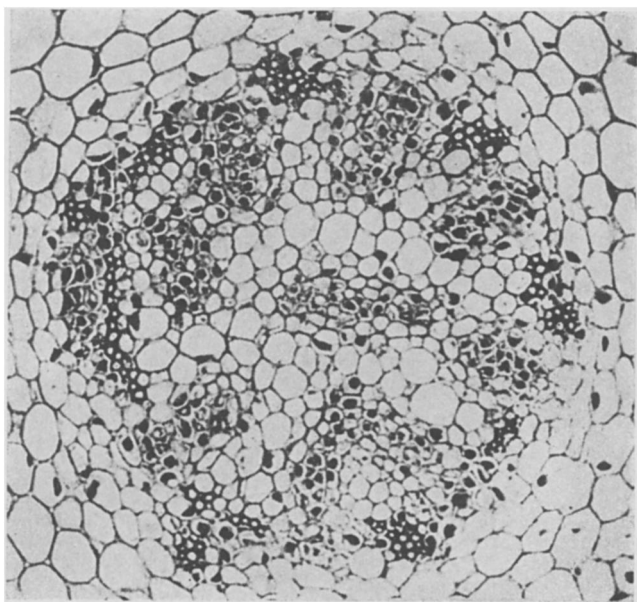


FIG. 2.—*L. reflexum*: transverse section through young stem tip showing several protoxylem points alternating with phloem in stele; phloem extends toward center of cylinder, alternating with unlignified metaxylem cells; there is a phloem island entirely surrounded by unlignified metaxylem cells; this arrangement when mature is represented in fig. 5; $\times 200$.

3 in a stem, are typical cortical roots (fig. 1). The stem of *Lycopodium reflexum* is small, about 1 mm. or less in diameter, with a very small stele, 0.2 mm. in diameter.

In stating the results of the investigation of the steles of the stem of *L. reflexum* I shall include simply a brief description of the steles found in the stems of various ages, omitting the details of the development of the types, which were given in the former article and do not seem to vary much in different species.

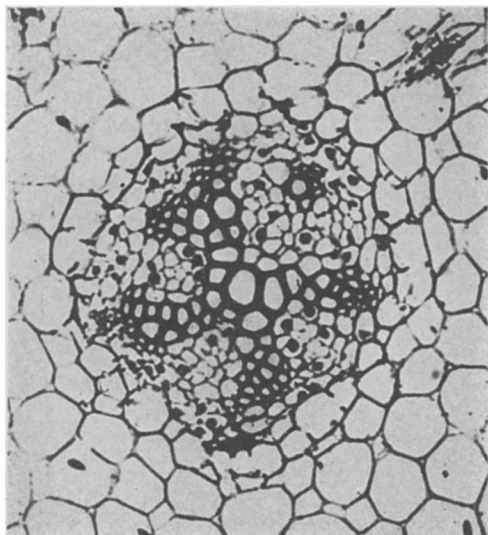


FIG. 3.—*L. reflexum*: stele showing radial arrangement of xylem with phloem located between protoxylem points and extending toward center of cylinder; $\times 200$.

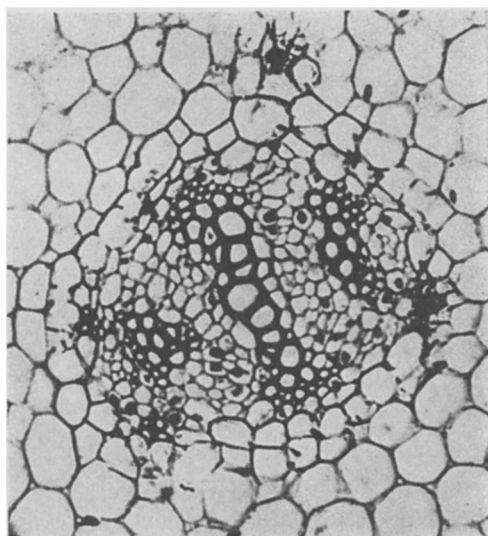


FIG. 4.—*L. reflexum*: stele showing parallel-banded arrangement of xylem with phloem occurring in bands alternating with xylem and extending across cylinder; $\times 200$.

The number of protoxylem points in the stem stele ranges from 4 to 11, with about 7 as the most frequent number. Sections of the young stem tip show the condition characteristic of *Lycopodium*, in which at about the time of differentiation of the protoxylem points the metaxylem cells are distinguishable by their large size and lack of protoplasmic content (fig. 2). There are 3 so-called types of stele to be found in *L. reflexum*: the radial arrangement (fig. 3), the parallel-banded arrangement (fig. 4),

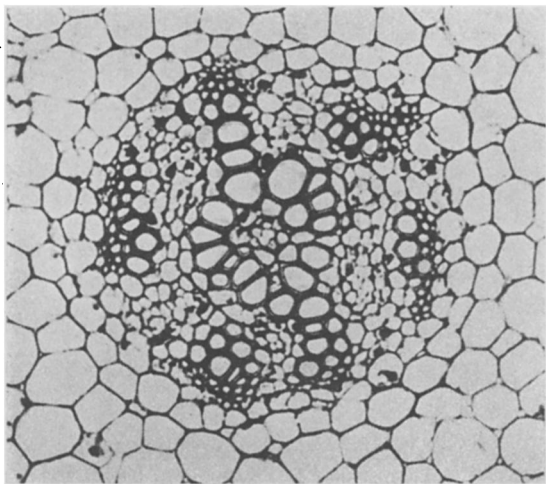


FIG. 5.—*L. reflexum*: stele showing inner cylinder of xylem surrounding strand of phloem, most frequent arrangement found in stele of *L. reflexum*; $\times 200$.

and an arrangement consisting of an inner cylinder of xylem surrounding a strand of phloem (fig. 5). These 3 arrangements of the xylem may be found in the same stem at different levels, and are all modifications of the radial arrangement. The parallel-banded arrangement, in which alternating strands of xylem and phloem occur in parallel bands across the cylinder, seems to be correlated to some extent with the growth of roots, since this arrangement is to be found most frequently in the region where the roots arise. The arrangement most frequently found is that consisting of an inner cylinder of xylem inclosing a strand of phloem (fig. 5). From this cylinder strands of xylem radiate to

the protoxylem points. The condition is very similar to the characteristic stele described for *L. Billardieri*. The inner cylinder does not remain intact through any great length of stem, but is frequently broken up and gives rise to a parallel-banded arrangement or reverts to the radial arrangement.

Summary

1. The 2 points of interest in the study of the anatomy of *Lycopodium reflexum* are the presence of typical cortical roots and the various "types" of stele in the stem.

2. The development and differentiation of the tissues in the steles of the cortical roots parallel those in the stele of the stem.

3. There are 3 arrangements of the xylem: radial, parallel-banded, and a radial arrangement so modified as to consist of an inner cylinder of xylem inclosing a small strand of phloem. The last is the most frequently found.

4. The study confirms my former suggestions that all arrangements of xylem may occur in the same stem in species of *Lycopodium*.

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